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ABSTRACT

This module on the circulatory system is one of 17 modules designed for individualized instruction in health occupations education programs at both the secondary and postsecondary levels. It is part of an eight-unit subset on anatomy and physiology within the set of 17 modules. Following a preface which explains to the student how to use the module, the unit consists of a pretest witn answers, five sections (information sheets) with their goals (e.g., identify the components of blood), optional activities (e.g., use a stethoscope to listen to heart sounds and identify which valves are making which sounds), posttests, and a glossary of terms. Topics covered in the unit are an introduction to the circulatory system, the blood, the heart, blood vessels, and the lymphatic system. An accompanying instructor's guide contains suggestions for using the module and answers to the posttest. (KC)

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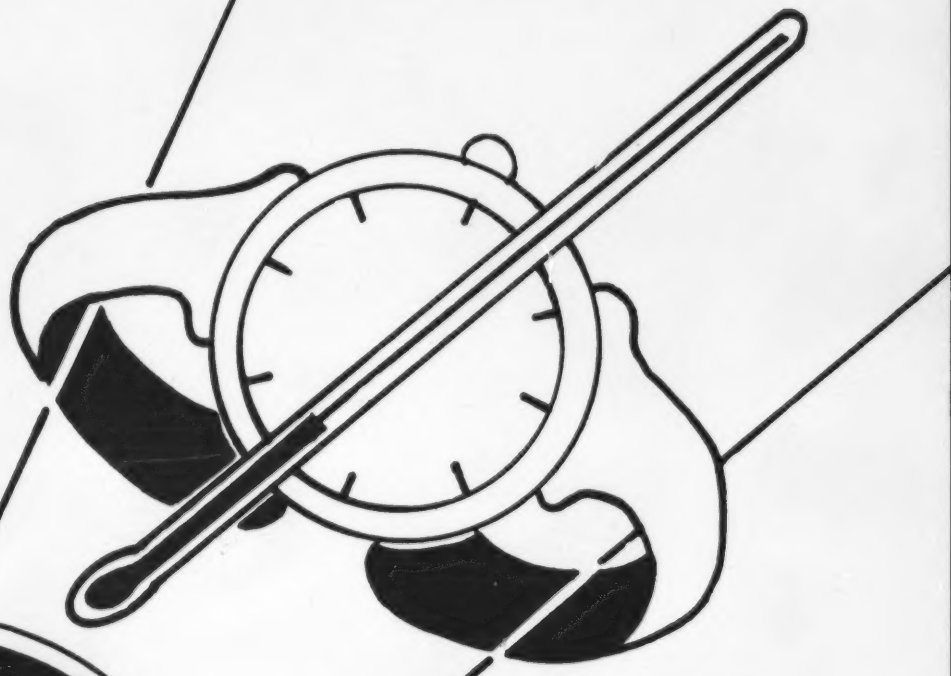

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THE CIRCULATORY SYSTEM

Instructional Materials in Anatomy and Physiology
for Pennsylvania Health Occupations Programs

THE CIRCULATORY SYSTEM

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June, 1979

PREFACE

An understanding of basic human anatomy and physiology is essential to any person preparing to enter a health occupation. This instructional unit is designed to introduce you to the structures and functions of the human circulatory system--and the interrelationships of the two--and to familiarize you with some of the terms and concepts necessary for an understanding of the circulatory system.

This unit consists of a pretest; five modules with their optional activities and post-tests; and a glossary of terms.

Begin this modular unit by taking the brief pretest at the front of the booklet. The pretest is for your use only, to give you an idea of what is included in this unit, and to give you an indication of the areas within the unit to which you should pay special attention (perhaps by working on the optional activities). When you have completed the pretest, turn to the answers in the back (page 39) to check your own score. You will not be graded on the pretest.

Next, read through each of the five modules (Introduction to the Circulatory System, The Blood, The Heart, Blood Vessels, and the Lymphatic System) and investigate any of the optional activities that may be helpful or interesting to you. The optional activities will help you learn more about some of the material presented.

At the end of this unit (page 37) is a glossary which provides you with brief definitions of many of the terms used in the modules.

Upon completion of each module, you should be able to demonstrate an understanding of the material presented, by your performance on the post-test. When you have finished a module and feel that you understand the information in that module, take the post-test that follows it. Write down your answers on ONE piece of paper and pass it in to your instructor, who will give you your grade.

PRETEST

1. Which of the following is a component of the circulatory system?

   A. brain
   B. lungs
   C. heart
   D. nerves

2. The fluid that flows through the circulatory system is called

   _____.

3. Red blood cells are also known as:

   A. monocytes.
   B. erythrocytes.
   C. osteocytes.
   D. basophils.

4. Which of the following plays the most important role in disease prevention?

   A. erythrocytes
   B. platelets
   C. plasma
   D. leukocytes

5. What is the heart's one continuous mechanical function?

   _____

6. Proper direction of blood flow through the chambers of the heart is maintained by:

A. coronary circulation.
B. atria.
C. arteries.
D. valves.

7. Which chamber of the heart pumps blood to the lungs?

_____

8. Which type of blood vessel has valves?

A. veins
B. arterioles
C. capillaries
D. arteries

9. Blood leaving the left ventricle of the heart FIRST travels through which artery?

A. brachial
B. aorta
C. carotid
D. femoral

10. Which of the following is a part of the lymphatic system?

A. kidneys
B. liver
C. spleen
D. intestine

INTRODUCTION TO THE CIRCULATORY SYSTEM

Goals

Upon completion of this module, you should be able to:

1. Identify the major components of the circulatory system.
2. Identify the major functions of the circulatory system.

A working system must have a way to carry materials produced in one area to other areas where they are needed and to remove those materials after they have been used. For example, underneath a city is a complex system of pipes used to carry fresh water to public buildings, factories, and homes, and to remove the water after it has been used. In the human body, the circulatory system serves this function: it carries fresh blood to every part of the body and removes the "used" blood and the waste products of cells. However, unlike the water supplied to a city, which is not returned to the reservoir but is dumped elsewhere, blood is constantly recycled: the same blood is used over and over again.

The major components of the human circulatory system are the blood, heart, and blood vessels (arteries, capillaries, and veins). In addition, this system includes the lymphatic system, which consists of lymph (a fluid closely related to blood), the lymphatics or lymph vessels, and the lymph nodes and related organs.

The most important function of the circulatory system is to transport oxygen and nutrients throughout the body, but the circulatory system serves several other functions: it removes the waste products of cell metabolism; it plays an important role in regulating and maintaining the conditions necessary for normal body functions; and the circulatory system protects the body through blood clotting and defending against disease. Although it is only one part of the system, the blood itself performs all of these functions; the heart, blood vessels, and lymphatic system are simply structures that help the blood perform its tasks properly.

Blood makes up about 7% of total body weight; thus, the volume of blood in a person's system varies with each person's body size, or weight. The circulatory system of a man who weighs 70 kilograms (154 pounds) contains five to six liters of blood. A woman of the same weight would have slightly less--about five liters. Children, of course, have smaller systems and therefore a smaller volume of blood.

INTRODUCTION TO THE CIRCULATORY SYSTEM

Post-Test

1. Arteries, capillaries, and veins are examples of:

   A. muscles.
   B. blood vessels.
   C. neurons.
   D. lymph nodes.

2. One function of the circulatory system is to:

   A. supply oxygen and nutrients to body tissues.
   B. process food in the body.
   C. transmit nerve impulses from the brain.
   D. manufacture vitamins.

3. Which of the following is actually a part of the circulatory system?

   A. respiratory system
   B. digestive system
   C. nervous system
   D. lymphatic system

4. An important function of the circulatory system is to:

   A. maintain body weight.
   B. break down carbohydrates.
   C. metabolize fats.
   D. fight diseases.

5. One way in which the circulatory system helps to protect the body is by:

A. surrounding vital organs.
B. supporting muscle tissue.
C. changing fluid volumes.
D. blood clotting.

THE BLOOD

Goals

Upon completion of this module, you should be able to:

1. Identify and describe the functions of blood.
2. Identify the components of blood.
3. Classify the major blood groups.

The red fluid we call blood is essential to every cell in the body. Although it appears to be a simple substance, blood is actually made up of a variety of parts. The most important of these are the formed elements, which include various types of blood cells, and the plasma, a special fluid which carries the formed elements. Plasma and each of the formed elements have important roles in the many functions of blood.

FUNCTIONS OF BLOOD

The blood's major functions can be divided into three categories; the first, and probably the most important, is to transport vital substances. Blood carries many substances to and from all parts of the body. These substances are either dissolved or suspended in the plasma, or attached to the formed elements during transport. Nutrients and oxygen, which are critical to cell life, are carried to the cells by both the plasma and blood cells. Metabolic wastes, the waste products produced by normal cell functions, are dissolved in the plasma and removed. Regulatory substances such as hormones and enzymes are transported by the blood from the areas where they are produced to the areas where they exert their effects.

Second, blood assists in the body's maintenance of homeostasis. Homeostasis can be defined as the process of constantly maintaining the proper balances necessary to normal body functioning. One of the ways in which blood contributes to maintaining homeostasis is by helping to regulate the body temperature: blood

absorbs heat produced by cells and carries it to the skin and lungs where it is given off. Blood also helps to maintain homeostasis by controlling the body's acid-base balance. For cell metabolism and other body functions, a certain balance between acids and bases is required; blood carries substances that maintain this balance and removes other substances that would upset this balance. Also, blood contributes to homeostasis by maintaining the proper level of fluid in body tissues, which often depends on the blood's ability to form clots to prevent excessive loss of blood.

Third, blood serves a protective function: disease prevention. Blood plasma contains antibodies that help to protect the body against disease, and some blood cells act specifically to protect the body against harmful organisms such as bacteria. All of these functions of the blood are vital to the body, and each function depends upon the special characteristics of the components of blood.

COMPONENTS OF BLOOD

The fluid portion of the blood is plasma, which makes up slightly more than half the total volume of the blood. Plasma is a clear yellowish liquid (often described at "straw-colored") in which the formed elements are suspended. Most of the plasma (90%) is made up of water. Plasma also contains various proteins, elements, salts, cell nutrients, and enzymes which give it its color and consistency and help the blood to maintain proper fluid and acid-base balance, as well as to prevent disease.

The three formed elements make up the rest of the blood volume (slightly less than half). Each of the formed elements has an important and distinct function.

First and most numerous of these formed elements are the erythrocytes, or red blood cells. A tiny drop of blood contains about 5 million erythrocytes. The body forms red blood cells in the red bone marrow at an incredible rate--roughly a drop of blood per second. This rapid rate of production is necessary since the life span of a red blood cell is only about 90-120 days. The high number of erythrocytes indicates their important role in blood function: these small disc-shaped cells are the oxygen carriers of the circulatory system. Their red color (which gives blood its color) is due to the fact that they contain hemoglobin, a very important substance that is responsible for the erythrocytes' ability to pick up and transport oxygen.

Hemoglobin, a substance which contains iron, helps blood to pick up oxygen in the lungs and carry it to cells throughout the body. Oxygen is needed constantly by every cell in the body.

Less numerous than the erythrocytes are the second of the formed elements in blood, the leukocytes. There are several types of these cells; some are produced in bone marrow, others are formed in the spleen and lymph nodes. Leukocytes are also called white blood cells because they lack the hemoglobin, and thus the red color, of the erythrocytes; but they have some interesting characteristics and abilities which red blood cells lack.

Leukocytes are capable of movement and can travel independently of blood flow. Although they are comparatively huge cells, leukocytes can travel through blood vessel walls and body tissues. They react to infection or inflammation: their numbers increase if an infection is present in the body, and they are chemically attracted to the site of the infection. Also, by a process called phagocytosis, leukocytes can engulf and destroy microscopic particles which may be harmful to the body. (For this reason, they are also called phagocytes.) These abilities are important because they help defend the body against disease and infection. The results of this leukocyte action can be seen as the yellowish-white pus that collects in an infected area; pus is a mixture of cell debris and white blood cells.

Platelets--the third of the formed elements--can also produce visible results. Smaller and more numerous than leukocytes, platelets contain a substance needed for blood clotting. When you cut yourself, the platelets in your blood release a substance that combines with other elements of the blood to form fibrin. Fibrin is a net of tiny fibers which forms a visible patch, or clot, over the cut. This patch of fibrin is often called a "scab." Blood clotting, or hemostasis, prevents the circulatory system from losing too much blood through any cut, large or small, in the system.

Figure 1 (see page 11) shows types and relative sizes of formed elements.

BLOOD GROUPS

Everyone has a certain blood type or blood group. Plasma and erythrocytes, and the way they react to each other, determine each individual's blood type. Blood types are very important when, for instance, a patient has lost so much blood that a transfusion is required. Someone would then donate blood to be given to the patient, but only certain types of blood are compatible with each other. The donor's blood would have to be compatible with that of the patient. The reasons for this can be explained through a description of the erythrocyte-plasma reaction.

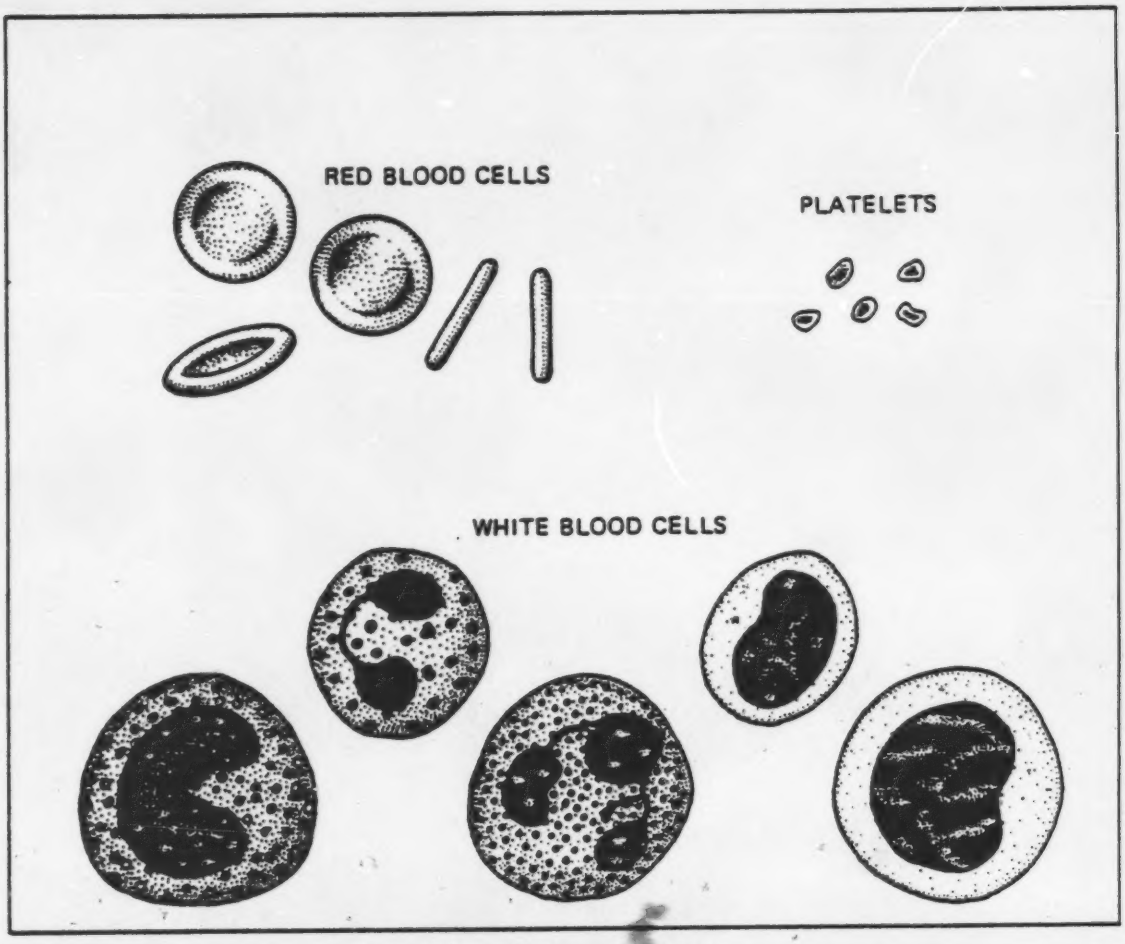


Figure 1. The Formed Elements

Blood types are determined according to two major systems: the ABO system and the Rh system.

On the surface of a person's erythrocytes are antigens which are designated as either type "A" or type "B". Blood plasma carries antibodies, which are compatible with either the A or B antigens on the erythrocytes and incompatible with the opposite type. For example, if type A red blood cells mix with the wrong type of plasma, an instant reaction occurs: the cells clump together, or agglutinate, a condition that makes the blood nonfunctional. The four blood types based on this erythrocyte-plasma reaction are: A, B, AB (the plasma lacks both antibodies), and O (the erythrocytes have neither substance A nor substance B). This constitutes the ABO system.

Blood type is also determined by the Rh System, or Rh factor, which is classified as either positive (+) or negative (-). About 85% of the population have Rh antigens on their red blood cells. Their blood is designated Rh positive. Blood without the antigens (about 15% of the population) is called Rh negative.

The most common blood type of O+, which means that the person has neither A nor B antibodies and has Rh antigens. The rarest blood type is AB- (both A and B antibodies are present on the erythrocytes but no Rh antigens are present).

Optional Activities

- View blood samples under a microscope. Can you identify the various types of cells?
- With a blood typing kit, determine your blood type. Then try determining the blood type of one of your classmates.
- Read about how the Rh factor affects child-bearing.
- Find out about "universal donor" and "universal recipient" blood types.

THE BLOOD

Post-Test

1. The liquid component of blood is called:

   A. fibrin.
   B. interstitial fluid.
   C. plasma.
   D. cerebrospinal fluid.

2. Leukocytes are also called:

   A. white blood cells.
   B. transport cells.
   C. clotting cells.
   D. plasma cells.

3. Which of the formed elements plays the most important role in blood clotting?

   _____

4. The most important component of red blood cells is:

   A. hemoglobin.
   B. glucose.
   C. plasma.
   D. carbon dioxide.

5. How is most of the oxygen in the bloodstream transported?

A. dissolved in plasma
B. bound to red blood cells
C. attached to platelets
C. carried by white blood cells

6. One way that blood helps to maintain homeostasis is by controlling:

A. metabolism.
B. body movements.
C. heat production.
D. body temperature.

7. Substances which are produced by all cells and must be removed by the bloodstream are called:

A. hormones.
B. acids and bases.
C. clotting factors.
D. metabolic wastes.

8. What are two regulatory substances that are transported by the blood?

_____

_____

9. Which of the following is NOT transported by the bloodstream?

A. phagocytes
B. urine
C. carbon dioxide
D. antibodies

10. What are the two major blood typing systems?

_____

_____

11. Which of the following blood types is the most common?

A. AB-
B. O+
C. A+
D. B-

12. Blood types are determined by interactions between:

A. leukocytes and interstitial fluid.
B. clotting factors and lymph.
C. erythrocyte antigens and plasma antibodies.
D. dissolved oxygen and circulating enzymes.

THE HEART

Goals

Upon completion of this module, you should be able to:

1. Identify the general characteristics of the heart.
2. Identify and describe the structures and functions of the heart.
3. Describe the movements of heart action.

The human heart is a muscular organ which is hollow and roughly cone-shaped, and about the size of a person's fist. Although it is only one part of the body's circulatory system, the heart is the powerhouse that makes the entire system function. Because it is such an important organ, the heart is positioned in a well-protected area. It is protected in the front of the chest by the sternum or breastbone, on the sides by the ribs, and by the spinal column in the back.

STRUCTURE OF THE HEART

The basic structure of the heart is simple but efficient. It is made up of three major layers: the pericardium, the myocardium, and the endocardium. The outer layer, the pericardium, is a tough skin or sac which surrounds the heart and serves both to protect and anchor it. The myocardium, the second layer, is the heart's muscle, the dynamo of the powerhouse. This is the layer responsible for the contractions that cause the heart's pumping action. The third layer, the endocardium, forms both the smooth inner lining of the heart and the heart's valves.

Within the heart are four chambers--two atria and two ventricles. The ventricles are separated by a thick wall of tissue called the septum. The two atria, which are at the top of the heart, have thinner walls and are smaller than the ventricles. Each atrium serves as a receiving area for blood coming from other parts of the body, which it then sends into the ventricle below. From the

ventricles, which are larger than the atria and have thicker, more muscular walls, blood is pumped through the body's entire circulatory system.

Inside the heart, and at the origins of the two large arteries leading from the heart, are four one-way valves which help to maintain the proper direction of blood flow. These valves open to permit blood to pass through, then clamp shut under back pressure produced by blood trying to flow the wrong way. The right atrioventricular or tricuspid valve lies between the right atrium and the right ventricle. The left atrioventricular valve, known as the bicuspid or mitral valve, is situated between the left atrium and left ventricle. The pulmonary semilunar valve guards the opening of the pulmonary artery and prevents blood pumped out of the right ventricle from flowing back into it. Similarly, the aortic semilunar valve lies at the origin of the aorta and snaps shut to prevent the flow of blood back into the left ventricle. You can hear the snapping shut of the valves when you listen to a "heartbeat", which is actually the sound of the two sets of valves at work.

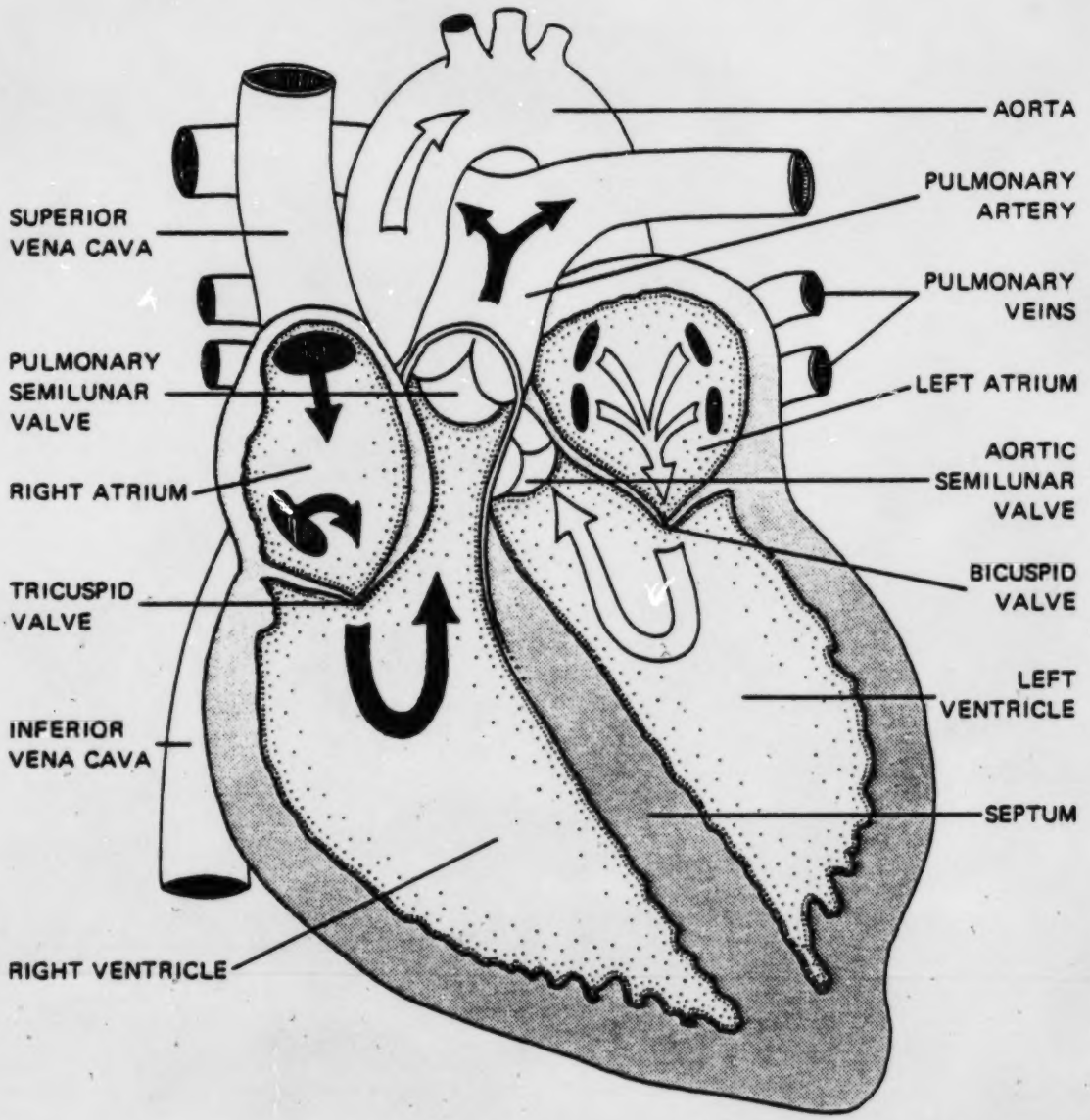
Figure 2 (see page 18) shows the structure of the heart and its associated valves and blood vessels.

FUNCTIONS OF THE HEART

The function of the heart is to pump blood; through the blood, oxygen and nutrients are carried to all body tissues, and waste products are carried away. Deoxygenated blood (blood which has already delivered most of its oxygen to the tissues of the body) enters the heart through the right atrium, and is pumped through the tricuspid valve to the right ventricle. The ventricle then contracts, forcing the blood through the pulmonary artery into the lungs. Oxygen is absorbed by the blood in the lungs, then flows back to the heart through the left atrium. (The flow of blood from the heart to the lungs and back to the heart again is called pulmonary circulation.) From the left atrium blood is sent through the bicuspid valve to the left ventricle. A powerful contraction then forces the blood into the aorta, where it branches off in different directions to all parts of the body. The flow of blood being pumped from the left ventricle to the body tissues and back to the heart is called systemic circulation.

Figure 3 (see page 19) is a schematic diagram showing the path of blood flow through the heart, lungs, and body.

The heart also has its own circulatory system, called coronary circulation. Two arteries, the coronary arteries, branch off from the base of the aorta to supply the heart muscle with the blood and nutrients that it needs.



Solid arrows indicate the path of flow of deoxygenated blood; open arrows the flow of oxygenated blood.

Figure 2. The Human Heart

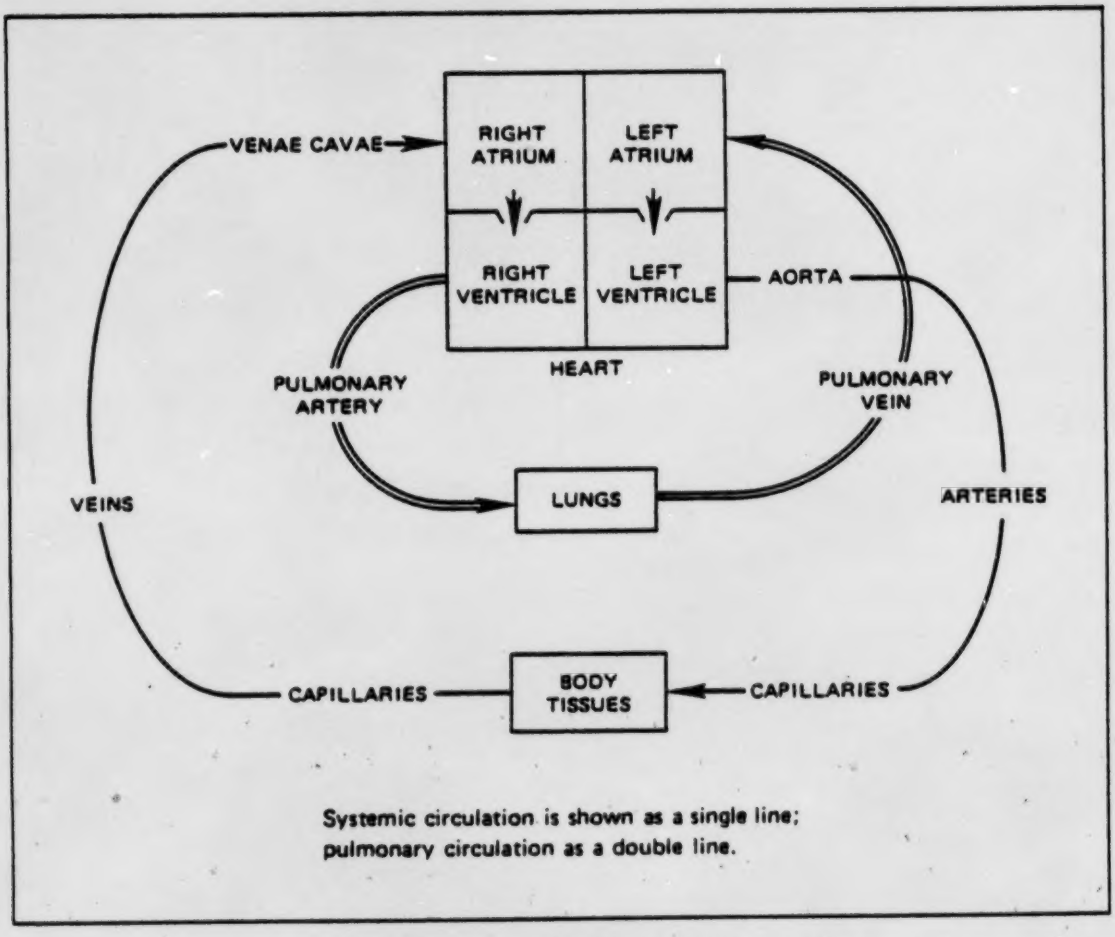


Figure 3. Schematic Diagram of Blood Flow Through the Body

Like other muscle tissue, heart muscle is stimulated by electrical impulses which produce muscle contraction--in this case, the contraction of the myocardium. Unlike other muscle tissue, heart muscle generates its own stimulating impulses. Two special masses or nodes of cardiac tissue, called the sinoatrial (SA) node, or "pacemaker," and the atrioventricular (AV) node, send out impulses that cause regular contractions of the heart.

Generally, the resting heart rate of a normal adult is 60 to 80 beats per minute. In children and infants the heart is smaller and beats faster. The heart rate also speeds up and slows down in response to changing body demands for oxygen and nutrients (e.g., during exercise).

The active or contracting phase of the ventricles is called systole. Contraction of the ventricles causes a burst or wave of blood to flow through the vessels, which can be felt at certain points of the body as a pulse. Diastole, the space or pause between pulsebeats, is the passive (relaxing or filling) phase of the ventricles. The measurement of blood pressure is expressed as the relationship of systolic pressure to diastolic pressure and can be a valuable indication of how effectively the heart is functioning.

The combined functions of the heart's natural "pacemaker," the chambers, and the valves produce the regular, continuous pumping action of the heart which sends waves of blood flowing throughout the body's circulatory system.

Optional Activities

- Find your pulse by placing your fingers against the side of your neck, wrist, or ankle and count the number of beats per minute while resting.
- Do some exercises and take your pulse rate immediately afterward and then 20 minutes afterward. What causes the changes?
- Use a stethoscope to listen to heart sounds. Can you identify which valves are making which sounds?
- Based on an average of 72 beats per minute, calculate how many times your heart beats per year.

THE HEART

Post-Test

1. Which of the following best describes the physical appearance of the heart?

   A. round and solid
   B. square and hollow
   C. cone-shaped and hollow
   D. triangular and solid

2. Name the three major layers of the heart.

   _____

   _____

   _____

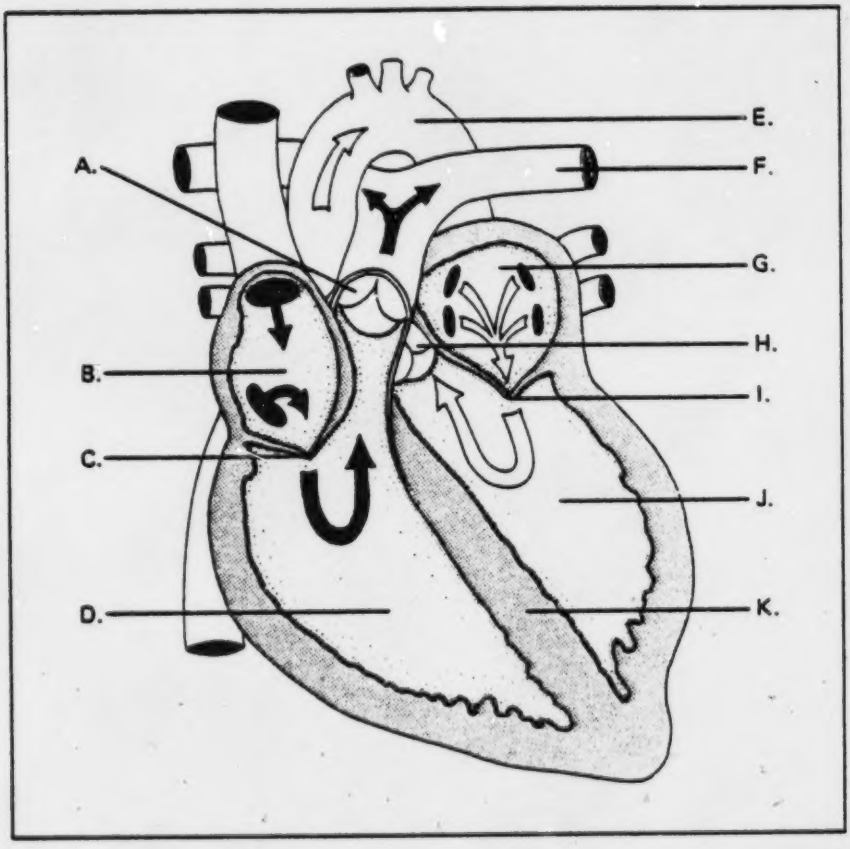
3. What layer of the heart contains the heart muscle?

   _____

4. The valve between the left atrium and left ventricle is the:

   A. bicuspid (mitral) valve.
   B. tricuspid valve.
   C. aortic semilunar valve.
   D. pulmonary semilunar valve.

5. Match the following parts of the heart to the corresponding letter. (Not all letters will be used.)



____ septum

____ tricuspid valve

____ left ventricle

____ right atrium

____ pulmonary semilunar valve

____ aorta

____ pulmonary artery

6. What are the names of the four chambers of the human heart?

_____

_____

_____

_____

7. What is the name for the flow of blood from the heart to the lungs and back to the heart?

_____

8. The active or pumping phase of heart action is also called:

A. systole.
B. deoxygenation.
C. homeostasis.
D. diastole.

9. The impulses which stimulate the heart to contract begin in the:

A. ventricles.
B. septum.
C. sinoatrial node.
D. valves.

10. The flow of blood from the left ventricle to all parts of the body and then back to the heart is known as:

A. systemic circulation.
B. diastolic pressure.
C. coronary circulation.
D. blood transport.

11. The normal resting heart rate of an adult is between:

A. 20-40 beats per minute.
B. 40-60 beats per minute.
C. 60-80 beats per minute.
D. 80-100 beats per minute.

BLOOD VESSELS

Goals

Upon completion of this module, you should be able to:

1. Identify and describe the structures and functions of arteries, capillaries, and veins.
2. Identify the major blood vessels of the body.

Blood must flow through distinct channels in order to travel from the heart to the body tissues and back again. These channels are provided by a network of blood vessels, called the vascular system, which directs the flow of blood through a one-way circuit. The entire vascular system is structured in a way that enables blood to circulate throughout the body, and to effect the exchange of materials, without escaping from the system. There are three types of blood vessels in the vascular system--arteries, capillaries, and veins--and each has different functions to fulfill.

ARTERIES

Arteries function as the channels which conduct the blood from the heart to the tissues. Arteries are constructed in three layers, called tunicae. The inner layer (tunica intima) is smooth and pliant. The middle layer (tunica media), which is the thickest layer in arteries, is made of muscular or elastic tissue. The elasticity of the middle layer enables the arteries to expand and contract to withstand the regular burst of blood sent out by each heartbeat. The outer layer (tunica adventitia) is composed of connective tissue. The smallest arteries, called arterioles, lack the outer tunica; because they carry or contain only small amounts of blood, they require only the two inner layers.

Most arteries carry oxygenated blood from the heart to the body. The oxygenated blood then flows from the major arteries through the arterioles and into the capillaries, where exchange with the body tissues takes place.

Exceptions to this are the pulmonary arteries, which carry deoxygenated blood from the heart to the lungs for oxygenation.

The major arteries begin with the aorta, which stems from the left ventricle of the heart and arches upward before curving down through the body. From the arch of the aorta branch off the carotid arteries, which rise through the neck to supply the head with blood (the carotid arteries are a good place to find a strong pulse); the subclavian arteries also branch off from the arch of the arorta and they in turn divide into the arteries supplying the chest. The arms and hands are supplied by the axillary arteries, which stem from the subclavians and branch into the brachial arteries in the arms and the radial and ulnar arteries in the forearms. The descending aorta passes through the chest and abdomen, where it branches off into the major internal arteries, including the renal arteries to the kidneys. Towards the legs, the abdominal aorta splits into the two iliac arteries, which descend into the legs to become the femoral arteries. These in turn branch into the arterial system of the lower legs and the feet.

CAPILLARIES

Arteries deliver blood through the arterioles to the microscopic, thin-walled capillaries, which are found in all of the tissues of the body. Because they have such a small diameter, the rate of blood flow slows down considerably in the capillaries--almost to one cell at a time. This helps the capillaries fulfill their function, which is to serve as the area where blood supplies nutrients and oxygen to body cells and removes waste materials. Capillary walls are extremely thin and are composed of one layer of smooth tissue that is only one cell thick; this allows the materials to seep in and out of the vessels. The capillaries can be thought of as the functional units of the vascular system--the vessels which serve the ultimate purpose of the entire circulatory system.

VEINS

Blood leaving the capillaries is drained (collected) by the venules. These are tiny veins which, like their counterparts the arterioles, have only two layers; they drain into larger veins, which are constructed in three layers like the arteries. Unlike the arteries, however, the middle layer of the vein walls is fairly thin; the thickest layer is the outer covering of connective tissue. The larger veins have one-way valves at regular intervals to keep the blood flowing toward the heart.

Veins carry the blood returning from the capillaries to the heart. Because of the small size of the capillaries, which have slowed blood flow, the blood has lost the driving pressure it had in the arteries, so the veins do not need the elasticity of the middle tunica as the arteries do. They do, however, need valves to keep the now comparatively sluggish blood flowing toward the heart. Venous blood flow is also helped by body movement as the muscles exert a massaging action on the veins to help push blood back to the heart.

Blood returning to the heart through the veins has lost most of its oxygen through the capillaries to the body tissues. Veins normally carry deoxygenated blood back to the heart, where it is pumped to the lungs for oxygenation. Exceptions to this are the pulmonary veins, which carry oxygenated blood to the heart from the lungs.

There are two classifications of veins. The deep veins are found next to and named similarly to the arteries: the subclavian veins, axillary veins, renal, iliac, and femoral veins, and so on. (Blood from the head, however, is collected by the jugular veins.) These veins drain the same areas supplied by the corresponding arteries. The superficial veins are closer to the skin than the arteries: in the legs, they are the saphenous veins, and in the arms, the cephalic and dorsal veins. These are the veins that you can see.

The large veins that flow into the right atrium of the heart form the superior vena cava, which drains the upper portion of the body, and the inferior vena cava, which drains the abdomen and legs. Blood flowing into the heart from the venae cavae has completed the circuit of the vascular system.

Figure 4 (see page 28) shows the structure of each of the three types of blood vessels.

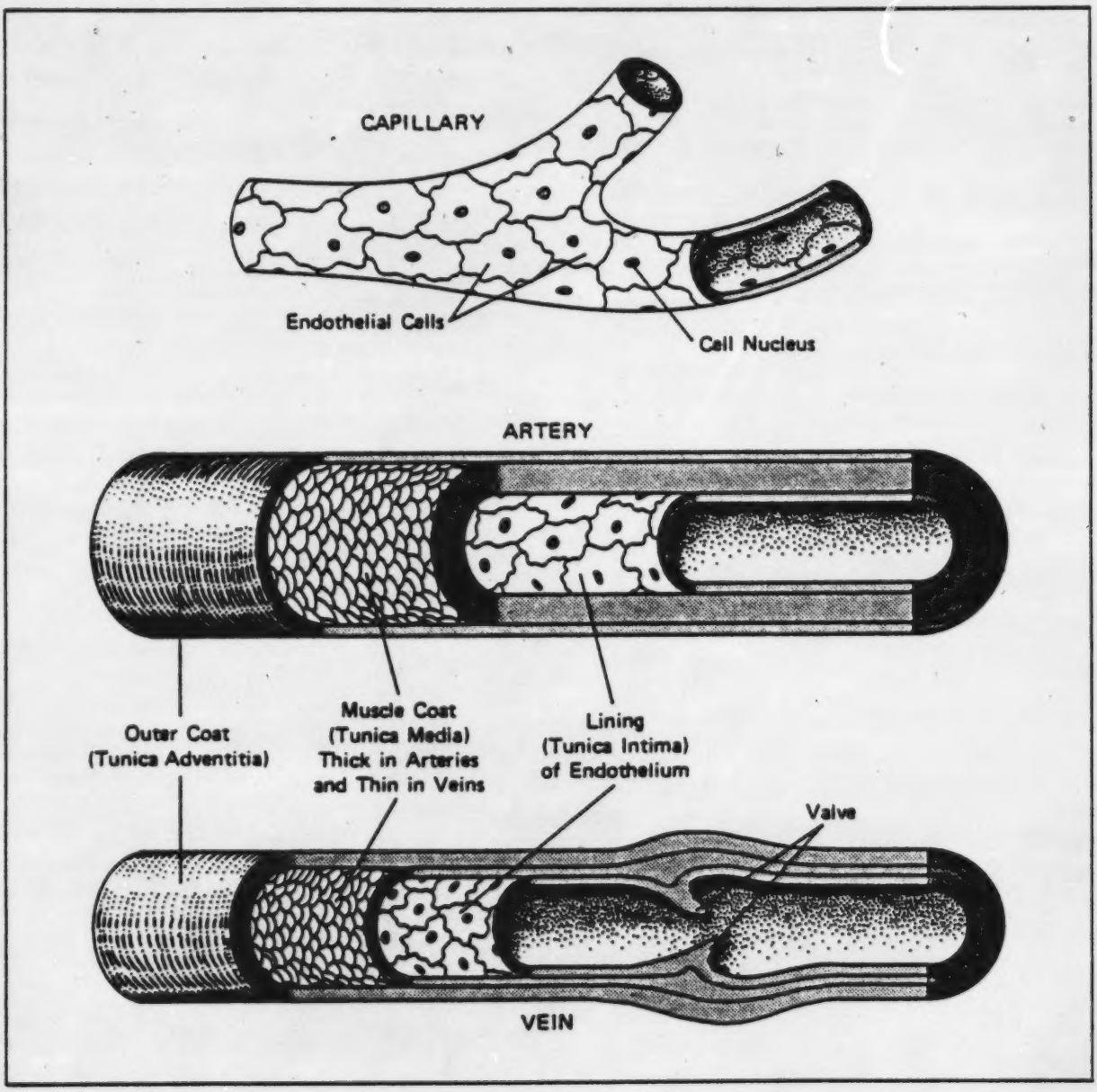


Figure 4. The Structure of the Blood Vessels

Optional Activities

- If you get a chance to see blood being drawn, can you tell whether it is arterial or venous? How?
- Why does standing upright without moving for long periods of time tend to make people faint? Why does elevating the legs of a person who has fainted help the person recover? How could fainting be prevented by people who must stand up all day?
- Use a diagram of the vascular system to locate the major arteries and veins of the body.

BLOOD VESSELS

Post-Test

1. Which of the following is NOT a part of the vascular system?

   A. veins
   B. capillaries
   C. lungs
   D. arteries

2. How many layers make up the walls of the large veins and arteries?

   _____

3. The veins usually carry:

   A. interstitial fluid.
   B. oxygen and nutrients.
   C. cerebrospinal fluid.
   D. deoxygenated blood.

4. The exchange of gases, nutrients, and wastes between the blood and the tissues takes place in what type of blood vessel?

   _____

5. What is the name of the vessel that carries blood from the right ventricle to the lungs?

   _____

6. The only veins that carry <u>oxygenated</u> blood to the heart are the:

A. saphenous veins.
B. subclavian veins.
C. renal veins.
D. pulmonary veins.

7. The two large veins which collect all of the blood returning to the heart and transport it to the right atrium are called the:

A. venae cavae.
B. iliacs.
C. hepatics.
D. femorals.

8. Which of the following collects blood returning from the head to the heart?

A. radial arteries
B. jugular veins
C. carotid arteries
D. axillary veins

THE LYMPHATIC SYSTEM

Goals

Upon completion of this module, you should be able to:

1. Identify the structures of the lymphatic system.
2. Identify and describe the functions of the lymphatic system.

Although not directly powered by the action of the heart, the lymphatic system is a part of the body's circulatory system and is closely linked to it in several ways. First, it resembles the systemic circulatory system in that it, too, is made up of a network of vessels through which a blood-like fluid flows. Also, the fluid within the lymphatic system, called lymph, is derived from and returns to the blood.

In the beginning of the discussion of the circulatory system, we compared it to the system of pipes used to deliver water to different parts of a city. Some water systems include filtering plants: the water is diverted through a filter where it is purified, then returned to the main system. In relation to the entire circulatory system, the lymphatic system acts as a filtering plant: it purifies the blood through a complex filtering process and returns it to the main circulatory system.

Lymph contains everything found in blood except the erythrocytes and the platelets; or, to put it another way, lymph is composed of blood plasma and leukocytes. (Actually, there are slight differences between plasma and lymph, mostly in the types and concentrations of proteins.) Plasma filters out of the capillaries into the spaces between body cells, where it becomes interstitial fluid. Some of this fluid returns to the capillaries, but most of it drains into the lymphatic capillaries; once there, it is called lymph.

Lymphatic capillaries are ideal collecting tubes because the lymph can pass through them much more easily than through the capillaries which transport blood. Because they are draining vessels rather than vessels of circulation, the lymphatic capillaries come to a "dead end" in the body tissues. However, they

drain into larger lymph vessels or lymphatics, which in turn drain into still larger lymphatics. These vessels have many valves in them to direct the flow of lymph towards its end: the thoracic duct, the body's largest lymphatic, which drains into the left subclavian vein in the neck. In this way the lymphatic system collects and returns the lymph to the bloodstream.

In draining tissues, the lymph must flow through small oval or roundish structures called lymph nodes. The lymph nodes are strung like hollow beads in clusters along the lymphatics, and are found throughout the body. They are especially rich in white blood cells, which help the lymphatic system fulfill its function in the body. The body fluids, interstitial fluid and plasma, enter the lymphatic system and filter through the lymph nodes. Here the white blood cells engulf and destroy undesirable microorganisms or particles, such as bacteria, bits of pollution, or cancerous cells. The fluid (now called lymph) then drains back into the circulatory system without these undesirable elements, which could cause a great deal of harm if circulated through the body. Thus the lymphatic system acts as the collector and purifier of the blood.

Lymph nodes also produce leukocytes, as do other organs in the body, such as the spleen and tonsils. The tonsils are actually three pairs of organs, located at the back of the oral and nasal cavities. They produce white blood cells which are sent into the lymphatics, and eventually into the bloodstream.

The spleen is a red, oval organ situated behind and to the left of the stomach. It has two main functions: like the tonsils, the spleen produces white blood cells and sends them into circulation. It is also the place where old red blood cells are destroyed and removed from the bloodstream.

Optional Activities

- View live amoebas under a microscope; observe how they move and how they ingest their food. Compare their actions to white blood cell actions.
- Have you had your tonsils removed? Find out and discuss the reasons why so many people have their tonsils taken out.
- Try to complete the word maze on the following page. It uses some of the terms that you learned in this unit.

WORD MAZE

A	T	U	M	V	D	E	A	B	D	R	O	C	U	M	A
P	R	L	E	A	R	N	L	O	I	M	U	T	P	E	S
P	I	N	T	C	I	V	E	N	A	C	A	V	A	D	T
E	P	A	S	U	D	Y	C	G	S	I	M	A	G	T	I
N	V	R	Y	N	R	I	G	H	T	O	R	S	O	N	G
D	E	N	S	E	E	T	Y	C	O	R	H	T	Y	R	E
O	N	A	H	V	A	R	E	K	L	A	B	R	A	I	N
M	U	K	R	C	S	E	L	Y	E	X	T	O	R	E	D
E	L	Z	E	T	A	R	M	I	R	A	S	Y	S	T	O
V	E	L	A	N	S	P	R	E	A	D	O	V	E	R	C
E	P	O	D	E	H	A	I	R	S	P	L	A	S	M	A
I	F	F	Y	N	E	G	I	L	E	G	A	L	I	T	R
L	I	E	O	O	A	P	R	O	L	E	G	O	M	E	D
O	L	D	E	R	V	I	S	T	R	A	I	G	H	K	I
S	E	T	Y	C	O	K	U	E	L	A	R	G	E	R	U
S	T	R	E	A	N	T	Q	U	A	S	H	Y	A	R	M

Find the following terms in this maze by circling the words. They may appear frontwards or backwards, vertically, horizontally, or diagonally.

capillary
diastole
endocardium
erythrocyte
leukocyte
lymph nodes
plasma
Rh system
septum
vena cava
venule

THE LYMPHATIC SYSTEM

Post-Test

1. Lymph is composed of:

   A. blood and bacteria.
   B. interstitial fluid and erythrocytes.
   C. lymphatics and capillaries.
   D. plasma and leukocytes.

2. The organs of the lymphatic system which filter the lymph and destroy bacteria are called

   _____.

3. The largest lymphatic in the body is the:

   A. thoracic duct.
   B. subclavian vein.
   C. lymphatic capillary.
   D. thymus.

4. An important function of the lymphatic system is to:

   A. produce and concentrate proteins.
   B. return fluids to the bloodstream.
   C. repair damaged capillaries.
   D. create interstitial fluid.

5. Along with lymph nodes, what two organs of the lymphatic system produce white blood cells?

_____

_____

GLOSSARY

ABO system: one of the major blood-typing systems.
acid-base balance: the balance between acids and bases within body tissues.
antibodies: proteins carried in the plasma.
antigens: proteins carried on red blood cells.
aorta: the great artery leading out of the left ventricle of the heart.
arteriole: a small artery.
artery: a large blood vessel which carries blood away from the heart.
atrioventricular node: a mass of conducting tissue near the base of the right atrium.
atrioventricular valve: a valve between an atrium and a ventricle.
atrium (pl. atria): one of the two small, upper chambers of the heart.

bicuspid (mitral) valve: the left atrioventricular valve.

capillary: a microscopic blood vessel or lymphatic.
coronary circulation: the flow of blood to and from the heart muscle.

deoxygenated blood: blood with most of its oxygen removed.
diastole: the relaxation phase of heart activity.

endocardium: the inner layer of heart tissue.
erythrocyte: a red blood cell.

formed elements: the cells and cell-like components of blood.

hemoglobin: the iron-containing component of red blood cells that binds with oxygen.
homeostasis: the state of normal balance of body functions.

jugular veins: large veins in the neck which drain blood from the head.

leukocyte: a white blood cell.
lymph: blood without red blood cells or platelets; the fluid of the lymphatic system.
lymphatics: vessels which carry lymph.
lymph nodes: masses of tissue along lymphatics which filter lymph.

myocardium: heart muscle, the middle of the three layers of the heart.

pericardium: the outer covering or membrane that surrounds the heart.
phagocytosis: engulfing of particles by cells.
plasma: the liquid portion of the blood.
platelets: one of the formed elements; they carry clotting factors.
pulmonary arteries: the vessels that carry blood from the right ventricle to the lungs.
pulmonary circulation: the flow of blood from the heart to the lungs and back to the heart.
pulmonary veins: the vessels that carry blood from the lungs to the heart.

Rh system: one of the major blood-typing systems.

semilunar valve: a valve at the base of a great artery (aortic or pulmonary) of the heart.
septum: a wall of tissue separating the ventricles.
sinoatrial node: a mass of tissue which acts as the heart's pacemaker.
spleen: an organ of the lymphatic system, located behind the stomach.
systemic circulation: the flow of blood from the heart to the body tissues and back to the heart.
systole: the active or contracting phase of heart action.

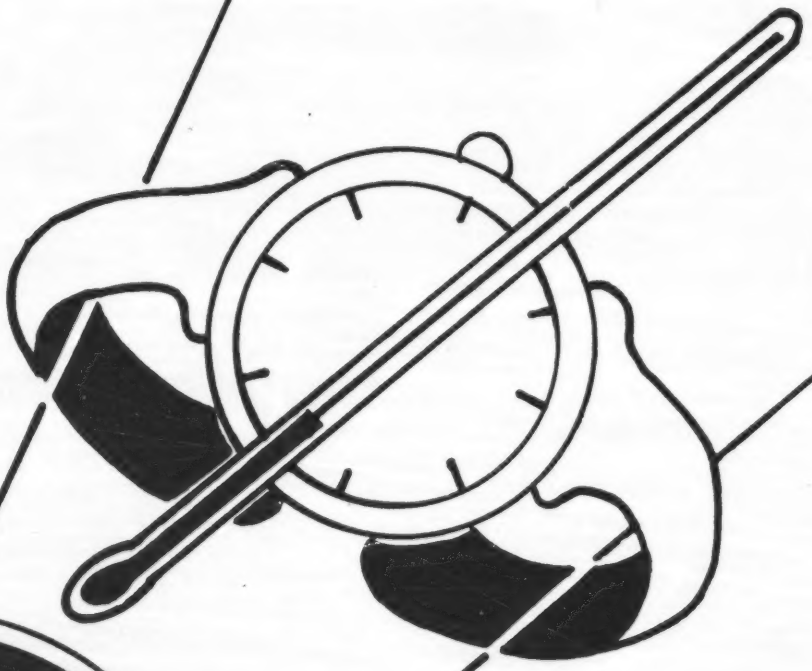
tonsils: organs of the lymphatic system, located on the sides of the throat at the back of the mouth.
tricuspid valve: the right atrioventricular valve.
tunica (pl. tunicae): one of the layers of blood vessels.

vascular system: the system of blood vessels.
vein: a large blood vessel which carries blood toward the heart.
venae cavae: the great veins that carry blood to the right atrium of the heart.
ventricle: one of the two large, lower chambers of the heart.
venule: a small vein.

ANSWERS TO THE PRETEST

Question	Correct Response
1	C
2	blood
3	B
4	D
5	pump blood (beat)
6	D
7	right ventricle
8	A
9	B
10	C

HEALTH OCCUPATIONS EDUCATION MODULE



INSTRUCTOR'S GUIDE

THE CIRCULATORY SYSTEM

Instructional Materials in Anatomy and Physiology
for Pennsylvania Health Occupations Programs

INSTRUCTOR'S GUIDE:

THE CIRCULATORY SYSTEM

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INTRODUCTION

These instructional modular units have been developed for the Pennsylvania Department of Education for use in vocational education programs. They were designed on the assumption that a basic understanding of human anatomy and physiology is essential to any person preparing to enter a health care occupation such as practical nursing, nursing assistant, medical assistant, emergency medical technician, or dental assistant. Each of these modular units will cover the most important aspects of one of the major systems of the human body. In the first four units the following systems will be covered: circulatory system, respiratory system, musculoskeletal system, and digestive system.

This Instructor's Guide is designed to provide suggestions to you on how to use a modular unit most effectively in your instruction. These recommendations, however, do not represent the only way to use these units: you may be able to devise more beneficial uses for the materials.

THE MODULAR UNITS

Each modular unit is made up of several components: a pretest, four to seven instructional modules with corresponding post-tests, optional activities for the students, and a glossary of terms used in the unit. Each of these components has a specific purpose and is organized in a specific way, as will be explained in the following sections.

Pretest

After reading the preface, which is simply an introduction to these instructional units, a student working through a modular unit should first take the pretest. As its name implies, this test is designed to be taken by the student before beginning work on the materials contained in the unit. Its purpose is twofold: (1) to stimulate interest in the modular unit by giving the student a preview of the topics covered, and (2) to provide a means of self-diagnosis so the student may identify, based on performance on the pretest, those areas of the

modular unit which may require special attention and extra effort on the part of the student. After selecting an answer to each of the pretest questions, the student should turn to the back of the modular unit and check the correct answers. If the student answers incorrectly on a number of questions dealing with a particular subject, then the student should pay closer attention to the module on that subject.

Instructional Modules

This modular unit is composed of five separate but closely related modules, including: Introduction to the Circulatory System, The Blood, The Heart, Blood Vessels, and The Lymphatic System. After taking the pretest and checking the answers, the student should read through and study each of the instructional modules. For the student's benefit, each module begins with a statement of the goals, or objectives, that a student should have mastered upon completion of that particular module. The level of achievement of these goals is measured by the student's performance on the corresponding post-test. The language level and content of each module is aimed toward the student seeking an introduction to the components, structures and functions, and the basic terminology required for an understanding of the circulatory system.

Optional Activities

Following many modules are optional activities intended to provide the student with an opportunity to pursue the content of the module at a more in-depth level. Many of these activities may require teacher participation, at least in obtaining and preparing additional materials for the student to utilize.

In addition to the optional activities available to the students, you may choose to provide further information to the students by teaching a brief unit on the common disorders of the circulatory system. Discussion of these disorders has not been included in the texts because a basic knowledge of the proper structure and function of the human body in a healthy individual seems more appropriate for the purposes of an introductory program. If you do choose to discuss common disorders, the most effective approach may be one in which you use disorders to illustrate what can go wrong in the body, as a means of clarifying the students' understanding of how the body works when functioning properly.

You may also wish to provide students with the names of books or articles as suggested readings to further their understanding of a particular area.

Glossary

After the last of the modules in the unit is a glossary. This is not intended to be a comprehensive glossary to be used by the student as a dictionary. Rather, it includes the basic terms used in the unit which are necessary to an understanding of the system covered. Those words which appear in the modules and have been defined in the text are not always defined in the glossary. Some of these particular terms have been used in the module because they are essential but difficult terms needed to explain the content taught in the unit. The student should use the glossary to review the vocabulary essential to the unit before taking the post-tests.

Post-Tests

The post-tests are the final assessment of a student's understanding of the material presented in each module. They consist of multiple-choice and open-ended questions designed to measure a student's mastery of the goals (objectives) stated at the beginning of each module. Each of the questions has been written to measure an aspect of the skills and/or knowledge that a student may be expected to acquire as a result of working through a particular module. When a student has finished studying a module, has pursued any chosen optional activities, and has reviewed the vocabulary in the glossary, the student should take the post-test that follows the module.

SCORING THE POST-TESTS

As previously mentioned, the purpose of the post-tests is to measure whether or not a student has mastered the objectives (goals) stated at the beginning of each module. Due to the differing lengths of the post-tests, the variety of ways in which teachers may choose to utilize these modules, and discrepancies among students' previous exposure to the subject matter, it is not practical to set a standard cut-off score on each of the tests that would indicate mastery of the objectives. Rather, teachers are asked to use their professional judgment in individual cases to determine if a student's performance on a post-test indicates that he or she has mastered the objectives stated for that module. In making this determination, you should consider at least all of the following factors:

(1) How long is each post-test?

(2) How much information is included in each module and how complex is the information, relative to other modules?

(3) Has the student been exposed to the kind of curricular material before? That is, has the student been taught the basics of this system of the body before?

(4) Should the entire class be required to achieve a certain score in order to pass, or should each student be considered individually? (This depends on how and with whom you use this module as instructional material.)

(5) Should the student be graded pass/fail on each post-test--i.e., on mastery of each module--or on the unit as a whole?

To facilitate the scoring of post-tests, each student will record his or her answers to all the post-tests on one separate sheet of paper. You should mark each answer correct or incorrect, then give the student a "pass" or "fail" on each module, or on the unit as a whole.

Because of the subject matter, responses to open-ended questions may vary slightly from those listed below, but these responses may also be acceptable. Again, in these cases instructors are asked to use their professional judgment to determine if a response is correct.

Use the following list of answers to questions on the post-tests to grade your students' papers.

ANSWERS TO THE CIRCULATORY SYSTEM POST-TESTS

Module/Question	Correct Response
Introduction to the Circulatory System:	
1	B
2	A
3	D
4	D
5	D
The Blood:	
1	C
2	A
3	platelets
4	A
5	B
6	D
7	D
8	hormones, enzymes
9	B
10	ABO, Rh
11	B
12	C
The Heart:	
1	C
2	pericardium, myocardium, endocardium
3	myocardium